

## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-357138

(43)Date of publication of application : 13.12.2002

(51)Int.Cl.

F02D 19/02  
 F02B 19/02  
 F02B 19/10  
 F02D 15/04  
 F02D 21/08  
 F02D 41/02  
 F02D 41/22  
 F02D 43/00  
 F02D 45/00  
 F02M 21/02  
 F02M 25/07

(21)Application number : 2001-163644

(71)Applicant : ISUZU MOTORS LTD

(22)Date of filing : 31.05.2001

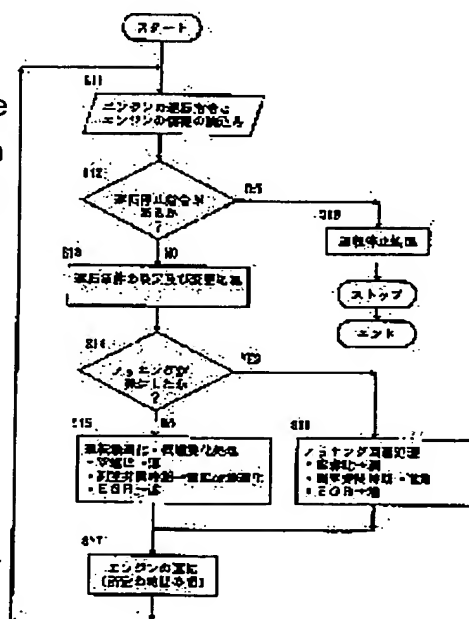
(72)Inventor : SASAKI YOJI

# (54) AUXILIARY CHAMBER TYPE GAS ENGINE WITH CONTROL VALVE AND OPERATION METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an auxiliary chamber type gas engine with a control valve capable of keeping the operation of the engine in an operation region of high thermal efficiency at all times, reducing NOx exhaust amount markedly with high thermal efficiency, and reducing combustion noises of the engine while avoiding the occurrence of knocking, and provide an operation method therefore.

SOLUTION: This auxiliary chamber type gas engine 1 with the control valve is provided with EGR system 47, 48, 49, a control means 50 for adjusting control valve opening time, an EGR gas flow rate, and an air-fuel ratio, and a knocking sensor 51 for detecting the occurrence of knocking. It is constituted such that the control for avoiding knocking is performed when the control means 50 detects the occurrence of knocking by the knocking sensor 51.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

**\* NOTICES \***

**JPO and NCIPi are not responsible for any damages caused by the use of this translation.**

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**CLAIMS**

---

[Claim(s)]

[Claim 1] By it being prepared between an accessory cell, the main rooms, and said accessory cell and said main rooms, having the control valve which opens in the pressing operation of a piston, supplying fuel gas to said accessory cell and said main rooms, making it light by said accessory cell, and opening said control valve The EGR system which is the accessory cell type gas engine which makes combustion of said main rooms start, returns a part of exhaust gas to an inhalation-of-air path, and is supplied to said main rooms with premixed air, While having the control means which adjusts a control valve open stage, an EGR gas flow rate, and an air-fuel ratio The accessory cell type gas engine with a control valve according to claim 1 characterized by performing knocking avoidance control when it has the knocking sensor which detects generating of knocking and said control means detects generating of knocking by said knocking sensor.

[Claim 2] the accessory cell type gas engine with a control valve according to claim 1 with which said control means is characterized for said knocking avoidance control by every cycle, every fixed time interval, any one for every gas column, or its thing [ carrying out by combining and coming out ].

[Claim 3] The accessory cell type gas engine with a control valve according to claim 1 or 2 characterized by said knocking avoidance control including any one or its combination of the increment in the tooth lead angle of a control valve open stage, reduction of an air-fuel ratio, and the amount of EGR(s).

[Claim 4] By it being prepared between an accessory cell, the main rooms, and said accessory cell and said main rooms, having the control valve which opens in the pressing operation of a piston, supplying fuel gas to said accessory cell and said main rooms, making it light by said accessory cell, and opening said control valve While having the control means which adjusts the EGR system which is made to start combustion of said main rooms, returns a part of exhaust gas to an inhalation-of-air path, and is supplied to said main rooms with premixed air, a control valve open stage and an EGR gas flow rate, and an air-fuel ratio The operating method of the accessory cell type gas engine with a control valve characterized by performing knocking avoidance control in the accessory cell type gas engine equipped with the knocking sensor which detects generating of knocking when generating of knocking is detected from the signal of said knocking sensor by said control means.

[Claim 5] the operating method of the accessory cell type gas engine with a control valve according to claim 4 characterized for said knocking avoidance control by every cycle, every fixed time interval, any one for every gas column, or its thing [ carrying out by combining and coming out ].

[Claim 6] The operating method of the accessory cell type gas engine with a control valve according to claim 4 or 5 characterized by performing said knocking avoidance control in any one or its combination of the increment in the tooth lead angle of a control valve open stage, reduction of an air-fuel ratio, and the amount of EGR(s).

---

[Translation done.]

**\* NOTICES \***

**JPO and NCIPI are not responsible for any damages caused by the use of this translation.**

1. This document has been translated by computer. So the translation may not reflect the original precisely.

2. \*\*\*\* shows the word which can not be translated.

3. In the drawings, any words are not translated.

---

**DETAILED DESCRIPTION**

---

[Detailed Description of the Invention]

[0001]

[Field of the Invention] In a gas engine, this invention has the main rooms and an accessory cell, and relates to the accessory cell type gas engine with a control valve which prepared the closing motion valve between this main rooms and accessory cell.

[0002]

[Description of the Prior Art] Mixing with the air (hydrogen) of natural gas, CO (carbon monoxide), H<sub>2</sub>, etc., etc. is difficult, and ignition temperature is high, and there are a jump-spark-ignition method, a direct injection method, a premixing compression ignition method, etc. in the gas engine which uses the fuel gas which cannot be lit easily.

[0003] In the gas engine of this jump-spark-ignition method, like a gasoline engine, after attaching a mixer, a single point fuel injection equipment, or a multipoint combustion fuel injection equipment in an inhalation-of-air path and making fuel gas into premixed air, it introduces into inside in a cylinder, and just before the top dead center in the second half of a compression stroke, the inhalation-of-air line of a piston lights premixed air with a spark plug, and is burned.

[0004] Since is put in practical use and the gas engine of this method cannot tend to knock easily from a gasoline engine, it can make a compression ratio high comparatively, and its thermal efficiency is also higher than a gasoline engine at about 37%.

[0005] However, although knocking-proof is high and can also make a compression ratio a little high rather than a gasoline engine, there are a problem that a compression ratio is restricted by generating of knocking and thermal efficiency is less than a diesel power plant, and a problem that an ignition becomes expensive and a complicated maintenance is needed.

[0006] Moreover, in the gas engine of a direct injection method, the fuel gas made into high pressure is injected and burned in a cylinder like a diesel power plant just before a compression top dead center. In this gas engine, a compression ratio is made just like a diesel power plant, and thermal efficiency also serves as the diesel-power-plant average.

[0007] However, since the equipment and the fuel injection equipment which compress fuel gas more than a compression top dead center pressure are needed, there is a problem that equipment becomes complicated, and an ignition is required, and this ignition becomes expensive like a jump-spark-ignition method, and there is a problem that a complicated maintenance is needed. Therefore, what was put in practical use does not have a small deer.

[0008] And in the gas engine of a premixing compression ignition method, the fuel was injected directly into the combustion chamber at the inhalation-of-air path or the compression stroke early stage, and the new combustion system to which self-ignition of the premixed air is carried out near a top dead center is adopted. Although current is in a research phase, thermal efficiency is high and serves as a gas engine super-low [ NO<sub>x</sub> ].

[0009] In this gas engine, it is easy to generate knocking which control of ignition near the compression top dead center of premixed air spreads in difficulty, and there is a problem that an operating range is narrow.

[0010]

[Problem(s) to be Solved by the Invention] In order to solve the trouble of the gas engine of this premixing compression ignition method, a combustion chamber is divided into the main rooms and

an accessory cell, a closing motion valve (control valve) is prepared in communication opening which opens for free passage both between the accessory cell and the main rooms of a piston crowning which were established in the cylinder head side, fuel gas is introduced into an accessory cell, air or premixed air is introduced into the main rooms, and the accessory cell type gas engine with a control valve which carries out compression ignition is developed.

[0011] While the fuel supply pressure has been low voltage by preparing a control valve in an accessory cell, this accessory cell type gas engine with a control valve By making possible compression ignition of the premixed air supplied to the main rooms, and controlling a control valve open stage Combustion of the main rooms can be controlled, the compression ignition engine which made an ignition and complicated direct injection equipment unnecessary can be realized by this, and there is big possibility as an engine that high thermal efficiency can moreover be attained.

[0012] However, since the fuel gas (hydrogen) of natural gas, CO (carbon monoxide), H<sub>2</sub>, etc., etc. is difficult for mixing with air and ignition temperature is as high as 800 degrees C or more also in this accessory cell type engine with a control valve, Since there is a property that combustion progresses at a stretch once ignition combustion takes place although it is hard to light, Premixed air flows into an accessory cell from the main rooms, when carrying out ignition combustion, combustion in an accessory cell is performed violently, there is a problem of being easy to generate knocking, and there is a problem that operation of a smooth engine and improvement in thermal efficiency are barred by generating of this knocking.

[0013] Since the temperature of each part of an engine will rise abruptly once knocking occurs especially, if still more intense knocking will occur and this intense knocking occurs, since a big pressure wave will go and come back to the inside of a cylinder, the pressure variation of a specific frequency will be produced and vibration and a sound will be generated, the problem that an engine is damaged or the engine noise increases arises.

[0014] This invention is made in order to solve an above-mentioned problem, it can maintain operation of an engine at a operating range with always high thermal efficiency, avoiding generating of knocking in an accessory cell type gas engine with a control valve, is high thermal efficiency, and is to offer few [ an NO<sub>x</sub> discharge is remarkable and / and ] accessory cell type gas engine with a control valve with an engine low combustion noise, and its operating method.

[0015]

[Means for Solving the Problem] The accessory cell type gas engine with a control valve for attaining the above purposes is constituted as follows.

[0016] 1) it prepares between an accessory cell, the main rooms, and said accessory cell and said main rooms -- having -- compression of a piston -- by having the control valve which opens in process, supplying fuel gas to said accessory cell and said main rooms, making it light by said accessory cell, and opening said control valve The EGR system which is the accessory cell type gas engine which makes combustion of said main rooms start, returns a part of exhaust gas to an inhalation-of-air path, and is supplied to said main rooms with premixed air, While having the control means which adjusts a control valve open stage, an EGR gas flow rate, and an air-fuel ratio, when it has the knocking sensor which detects generating of knocking and said control means detects generating of knocking by said knocking sensor, it is constituted so that knocking avoidance control may be performed.

[0017] 2) Moreover, in the above-mentioned accessory cell type gas engine with a control valve, said control means is constituted so that said knocking avoidance control may be performed in every cycle, every fixed time interval, any one for every gas column, or its combination.

[0018] 3) And in the above-mentioned accessory cell type gas engine with a control valve, it is constituted so that said knocking avoidance control may include any one or its combination of the increment in the tooth lead angle of a control valve open stage, reduction of an air-fuel ratio, and the amount of EGR(s).

[0019] Moreover, the operating method of the accessory cell type gas engine with a control valve for attaining the above purposes is constituted as follows.

[0020] 1) it prepares between an accessory cell, the main rooms, and said accessory cell and said main rooms -- having -- compression of a piston -- by having the control valve which opens in process, supplying fuel gas to said accessory cell and said main rooms, making it light by said

accessory cell, and opening said control valve While having the control means which adjusts the EGR system which is made to start combustion of said main rooms, returns a part of exhaust gas to an inhalation-of-air path, and is supplied to said main rooms with premixed air, a control valve open stage and an EGR gas flow rate, and an air-fuel ratio In the accessory cell type gas engine equipped with the knocking sensor which detects generating of knocking, when generating of knocking is detected from the signal of said knocking sensor by said control means, it is constituted so that knocking avoidance control may be performed.

[0021] 2) Moreover, set to the operating method of the above-mentioned accessory cell type gas engine with a control valve, and it is [ every cycle and ] every fixed time interval about said knocking avoidance control. It is constituted so that it may carry out in any one or its combination for every gas column.

[0022] 3) And in the operating method of the above-mentioned accessory cell type gas engine with a control valve, it is constituted so that said knocking avoidance control may be performed in any one or its combination of the increment in the tooth lead angle of a control valve open stage, reduction of an air-fuel ratio, and the amount of EGR(s).

[0023] According to the accessory cell type gas engine with a control valve and operating method of the above configuration, since it is made the operational status which knocking cannot generate easily due to any one or its combination of the tooth lead angle of a control valve open stage, the increment in an EGR flow rate, and reduction of an air-fuel ratio according to an engine operation situation when knocking has been sensed by the knocking sensor, generating of intense knocking can be avoided and operational status can be maintained in the good condition.

[0024] In addition, the same thing as a diesel knock to which the rate of a pressure buildup becomes excessive in early stages of combustion is also included in this knocking.

[0025]

[Embodiment of the Invention] Hereafter, the accessory cell type gas engine with a control valve concerning this invention and its operating method are explained, referring to a drawing.

[0026] Drawing 1 is drawing showing the configuration of the combustion chamber of the accessory cell type gas engine with a control valve concerning this invention, and drawing 2 is drawing showing the system configuration of an accessory cell type gas engine with a control valve. And drawing 3 is drawing showing the flows of control of engine operation.

[0027] As shown in drawing 1 , for each [ \*\* and ] cylinder of every, the configuration of the combustion chamber of this accessory cell type gas engine 1 with a control valve has a cylinder 11, the main rooms 13 formed in the upper part of a piston 12, and this main room 13 and the accessory cell 14 which is open for free passage through the closing motion section of a control valve 15, and is constituted. This cylinder 11 consists of head liner 11a and cylinder liner 11b, and an accessory cell 14 is formed in the cylinder head 17.

[0028] the control valve open stage adjustable equipment 16 controlled by the controller (ECU) 50 which is a control means so that this control valve 15 is shown in drawing 2 -- minding -- compression of a piston 12 -- it constitutes so that it may open in process.

[0029] As shown in drawing 2 , and this accessory cell type gas engine 1 with a control valve The engine 10 equipped with the main rooms 13 and an accessory cell 14, a supercharger 20, and the 1st fuel-supply path 30 that supplies fuel gas F to the main rooms 13, It has the 2nd fuel-supply path 35 which supplies fuel gas F to an accessory cell 14, the inhalation-of-air path 40 which supplies Air A to the main rooms 13, the flueway 45 which discharges exhaust gas G, and the EGR path 47 for carrying out recycling of EGR gas germanium, and is constituted.

[0030] The 1st fuel-supply path 30 is formed so that it may have the 1st fuel-flow control unit 31 and the 1st fuel supply system 32 and may be open for free passage in the main rooms 13, while connecting with the source of supply of fuel gas F, and the 2nd fuel-supply path 35 is formed so that it may have the 2nd fuel-flow control unit 36 and the 2nd fuel supply system 37 and may be open for free passage accessory cell 14, while connecting with the source of supply of fuel gas.

[0031] Moreover, the inhalation-of-air path 40 is connected with the main rooms 13 via the compressor 21 of a supercharger 20 through air control-of-flow equipment 41, and, on the other hand, opens for free passage the flueway 45 which comes out of an engine 10 with the open air via the turbine 22 grade of a supercharger 20.

[0032] The EGR path 47 is equipped with the EGR flow rate control device 48 and EGR cooler 49 which consist of EGR valves etc., from a turbine 22, connects the flueway 45 of the downstream, and air control-of-flow equipment 41 and the inhalation-of-air path 40 between compressors 21, and is formed. In addition, this EGR cooler 49 cools EGR gas germanium, and plays the role which controls generating of NOx.

[0033] That is, while having the 1st and 2nd fuel-supply paths 30 and 35 which supply fuel gas F to both an accessory cell 14 and the main rooms 13, it has the EGR path 47 of exhaust gas G which returns germanium to the inhalation-of-air path 40 in part, and is supplied to the main rooms 13 with premixed air.

[0034] Furthermore, although not illustrated, the knocking sensor 51 which detects generating of knocking is arranged by the engine 10. As this knocking sensor, there is a thing of an approach which detects vibration of a cylinder crank case, cylinder pressure, a combustion noise, etc.

[0035] Although this vibration level is detected by the approach of detecting vibration of this cylinder crank case since a cylinder block etc. is attached and the vibration level of a specific frequency becomes large according to generating of knocking, there are a piezo-electric formula knock sensor and a magnetostriction type knock sensor in this oscillating detection type.

[0036] And a controller (ECU) 50 inputs engine information, such as an engine rotational frequency, knocking, a flame failure, Pmax, a fuel flow, an air flow rate, an EGR gas flow rate, an intake-air temperature, a MAP, an exhaust-gas temperature, exhaust gas pressure, and a crank angle. Control valve open stage adjustable equipment 16, a supercharger 20, the 1st fuel-flow control unit 31, the 2nd fuel-flow control unit 36, air control-of-flow equipment 41, the EGR flow rate control unit 51, and EGR cooler 52 grade are controlled. It is constituted so that adjustment control of the valve-opening stage of a control valve 16, an EGR gas flow rate, the air-fuel ratio, etc. may be carried out.

[0037] Control of this EGR gas flow rate is adjusting an EGR gas flow rate by adjustment control of the EGR flow rate control units 51, such as an EGR valve, and control of an air-fuel ratio is performed by adjustment of a fuel flow by adjustment control of the 1st fuel-flow control unit 31 and the 2nd fuel-flow control unit 36, and adjustment of the air flow rate by control of a supercharger 20 and adjustment control of air control-of-flow equipment 41.

[0038] Next, the combustion method of the gas engine which used this accessory cell type gas engine 1 with a control valve is explained.

[0039] In this accessory cell type gas engine 1 with a control valve, if the gaseous mixture and EGR gas germanium with which fuel gas F and Air A mixed fuel gas F to the accessory cell 14 at the main rooms 13 are introduced, respectively and a control valve 15 is opened at the suitable stage of the compression stroke of a piston 12, the gaseous mixture and EGR gas germanium of the main rooms 13 will flow into an accessory cell 14 quickly, and will form gaseous mixture in an accessory cell 14.

[0040] And if a piston 12 approaches a top dead center, the gaseous mixture formed in the accessory cell 14 by the temperature rise by compression lights first, by expansion of the gas which burned with this ignition, and descent of a piston 12, the combustion gas of an accessory cell 14 will blow off in the main rooms 13, hot combustion gas will be mixed with the gaseous mixture of the main rooms 13, and the gaseous mixture of the main rooms 13 will light.

[0041] At this time, combustion can be considered as the moderate combustion which does not cause knocking by making optimum dose EGR gas germanium exist in the main rooms 13. And since combustion of this main room 13 is the self-ignition of premixed air, in spite of moderate combustion, a heat rate pattern has a high peak and a combustion period serves as short good combustion of cutting which burns.

[0042] The heat release pattern of this whole is the pattern of two crests where the low peak by combustion of the accessory cell 14 in the first half of combustion and the high peak by combustion of the main rooms 13 in the second half appear. The low peak of this first half stops the excessive pressure buildup by combustion of the second half, and is carrying out the role which realizes quiet combustion. And the discharge of NOx serves as a very low value used as 1 / 10 - 1/100 of a diesel power plant. By always performing such combustion, it is efficient and becomes combustion super-low [ NOx ].

[0043] And since a service condition is restricted by generating and the flame failure of excessive

knocking while being greatly influenced with the valve-opening stage of a control valve 15, an EGR rate, and an air-fuel ratio, it is necessary to maintain combustion of this accessory cell type gas engine 1 with a control valve at the always optimal conditions. Especially generating of knocking has the large effect of a control valve open stage and an EGR rate.

[0044] By then, the controller 50 which inputs the detection value of the knocking sensor 51 When it monitors continuously while operating generating of knocking, and the operational status of engines, such as each part temperature of an engine, a MAP, and exhaust gas pressure, and knocking has not occurred When it is set as the optimum conditions according to train operation dispatching and knocking occurs, a control valve open stage, an EGR rate, and an air-fuel ratio are further controlled for every gas column if needed every cycle and the whole fixed period, and always optimal combustion is realized.

[0045] Next, an engine operation flow is explained, referring to drawing 3.

[0046] If operation of an engine is started and flows of control start, the information on engine that an engine condition is indicated to be train operation dispatching about operation of an engine at step S11 will be read.

[0047] An engine target engine speed, an engine target load, etc. are contained in this train operation dispatching, and the engine engine speed which shows an engine condition, knocking, a flame failure, Pmax, a fuel flow, an air flow rate, an EGR gas flow rate, an intake-air temperature, a MAP, an exhaust-gas temperature, exhaust gas pressure, a crank angle, etc. are included in the information on engine.

[0048] And if it judges whether they are whether there is any shutdown command and no to train operation dispatching of this read engine and is in it at the following step S12, it goes to step S18, shutdown processing of an engine is performed, and this control is stopped.

[0049] At this step S12, if there is no shutdown command, based on train operation dispatching of the engine gone and read into the following step S13, and the information on engine, processing of a setup or modification will be performed for operation parameters, such as fuel quantity, an air-fuel ratio, a valve-opening stage of a control valve 15, and an EGR gas flow rate.

[0050] and at the following step S14, when it judges whether knocking occurred or not and it is judged as knocking having not occurred Perform operation optimization and low-fuel-consumption-ized processing of step S15, and an operation parameter is updated. When it judges with having performed operation of an engine between time amount predetermined at step S17, and knocking having occurred Knocking evasion processing of step S16 is performed, an operation parameter is updated and operation of an engine is performed between time amount (interval of control of an engine) predetermined at step S17.

[0051] Knocking evasion processing of one step S16 contains the processing which makes an air-fuel ratio deep, the processing to which the tooth lead angle of the accessory cell valve-opening stage is carried out, and the processing which increases an EGR gas flow rate (EGR rate) including the processing whose operation optimization and low-fuel-consumption-ized processing of this step S15 makes an air-fuel ratio thin, and the processing which decreases a lag or the processing made to optimize, and an EGR gas flow rate (EGR rate) in an accessory cell valve-opening stage.

[0052] And operation based on these flows of control is continued until an engine shutdown command will come out of operation of return and an engine to step S11, if operation of the engine between the predetermined time amount of this step S17 is ended.

[0053] According to the accessory cell type gas engine 1 with a control valve and operating method of this configuration, engine operation can be performed at a high thermal efficiency point, preventing generating of knocking by controlling a control valve open stage, an EGR rate, and an air-fuel ratio by the approach by feedback control etc. for every cycle, every fixed period, and every cylinder, supervising generating of knocking by the knocking sensor 51 and the controller 50.

[0054]

[Effect of the Invention] Engine operation can be performed at an always high thermal efficiency point, always preventing generating of knocking by controlling a control valve open stage, an EGR rate, and an air-fuel ratio for every cycle, every fixed period, and every cylinder, supervising generating of knocking according to the accessory cell type gas engine with a control valve and operating method of this invention, as explained above.



[0055] Therefore, an engine combustion noise can operate in the low condition an NOx discharge is remarkable and few with high thermal efficiency within a operating range with always high thermal efficiency, avoiding generating of knocking.

[0056] Therefore, low fuel consumption and a low-pollution engine can be realized, and ignition and combustion serve as an engine applicable also to liquid fuel, such as difficult alcohol fuel and a gasoline, by the further usual diesel power plant.

---

[Translation done.]

**\* NOTICES \***

**JPO and NCIPi are not responsible for any damages caused by the use of this translation.**

1. This document has been translated by computer. So the translation may not reflect the original precisely.

2. \*\*\*\* shows the word which can not be translated.

3. In the drawings, any words are not translated.

---

**DESCRIPTION OF DRAWINGS**

---

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the configuration of the combustion chamber of the accessory cell type gas engine with a control valve of the gestalt of operation concerning this invention.

[Drawing 2] It is drawing showing the system configuration of the accessory cell type gas engine with a control valve of the gestalt of operation concerning this invention.

[Drawing 3] It is drawing showing the flows of control of operation of the accessory cell type gas engine with a control valve of the gestalt of operation concerning this invention.

[Description of Notations]

1 Accessory Cell Type Gas Engine

12 Piston

13 The Main Rooms

14 Accessory Cell

15 Control Valve

40 Inhalation-of-Air Path

47 EGR Path

48 EGR Gas Flow Rate Control Unit (EGR Valve)

49 EGR Cooler

50 Controller (Control Means)

51 Knocking Sensor

F Fuel gas

G Exhaust gas

germanium EGR gas

---

[Translation done.]

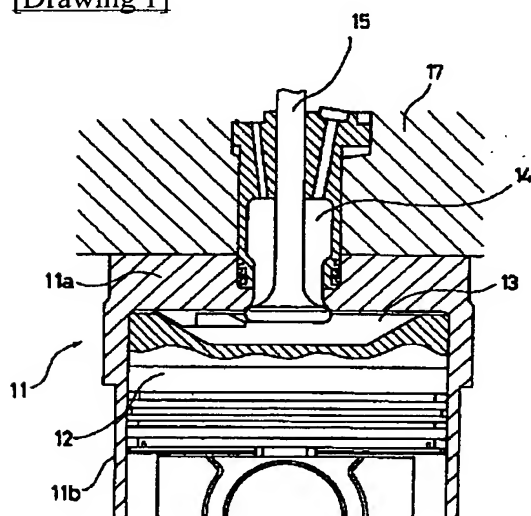
## \* NOTICES \*

JPO and NCIPi are not responsible for any damages caused by the use of this translation.

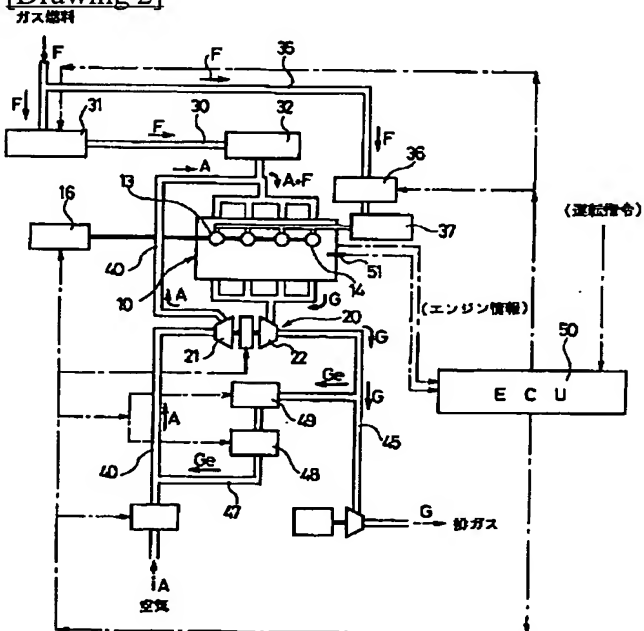
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DRAWINGS

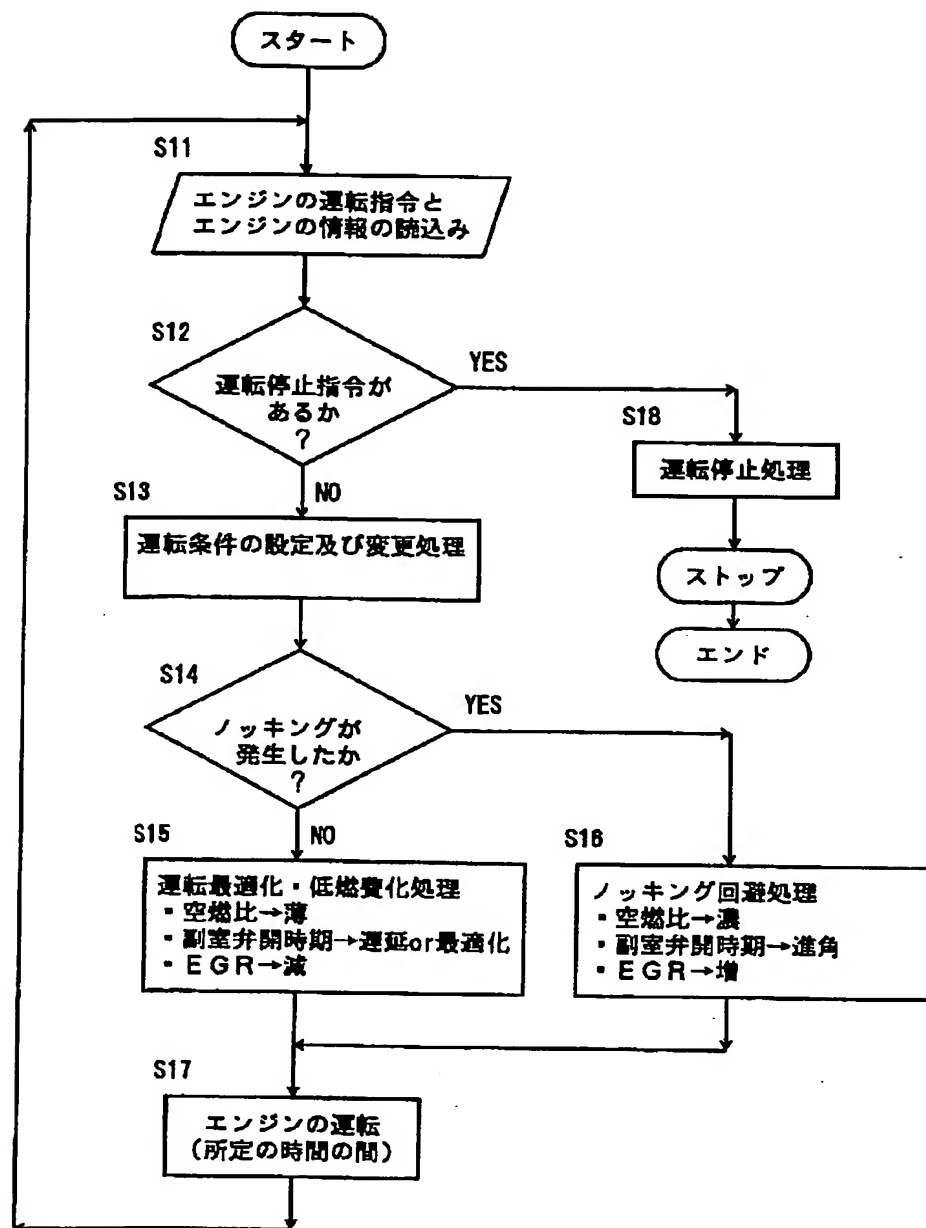
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]

(19) 日本国特許庁 (J P)

# (12) 公開特許公報 (A)

(11) 特許出願公開番号

特開2002-357138

(P 2002-357138A)

(43) 公開日 平成14年12月13日 (2002. 12. 13)

(51) Int. Cl. <sup>7</sup>

F02D 19/02

識別記号

F I

F02D 19/02

テマコード (参考)

F 3G023

B 3G062

D 3G084

3G092

G 3G301

F02B 19/02

F02B 19/02

19/10

19/10

審査請求 未請求 請求項の数 6 O L (全 8 頁) 最終頁に続く

(21) 出願番号 特願2001-163644 (P 2001-163644)

(22) 出願日 平成13年 5 月31日 (2001. 5. 31)

(71) 出願人 000000170

いすゞ自動車株式会社

東京都品川区南大井 6 丁目26番 1 号

(72) 発明者 佐々木 洋士

神奈川県藤沢市土棚 8 番地 株式会社いすゞ

セラミックス研究所内

(74) 代理人 100066865

弁理士 小川 信一 (外 2 名)

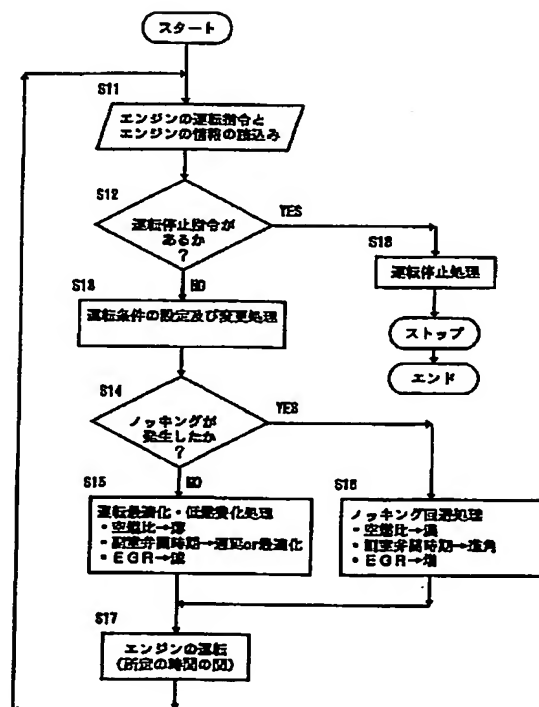
最終頁に続く

(54) 【発明の名称】 制御弁付き副室式ガスエンジンとその運転方法

(57) 【要約】

【課題】 制御弁付き副室式ガスエンジンにおいて、ノッキングの発生を回避しながら、エンジンの運転を常に熱効率の高い運転領域に保つことができ、高い熱効率で、NOx 排出量が著しく少なく、また、エンジンの燃焼騒音が低い制御弁付き副室式ガスエンジン及びその運転方法を提供する。

【解決手段】 制御弁付き副室式ガスエンジン 1 において、EGR システム 47、48、49 と、制御弁開時期と EGR ガス流量と空燃比を調整する制御手段 50 を備え、ノッキングの発生を検知するノッキングセンサ 51 を備え、前記制御手段 50 が、前記ノッキングセンサ 51 によりノッキングの発生を検知した時に、ノッキング回避制御を行うように構成する。



## 【特許請求の範囲】

【請求項 1】 副室と主室と、前記副室と前記主室の間に設けられ、ピストンの圧縮工程中に開弁する制御弁とを備え、ガス燃料を前記副室と前記主室に供給し、前記副室で着火させて、前記制御弁を開弁することにより、前記主室の燃焼を開始させる副室式ガスエンジンであって、排ガスの一部を吸気通路に戻し、前記主室へ予混合気とともに供給する EGR システムと、制御弁開時期と EGR ガス流量と空燃比を調整する制御手段を備えると共に、ノッキングの発生を検知するノッキングセンサを備え、前記制御手段が、前記ノッキングセンサによりノッキングの発生を検知した時に、ノッキング回避制御を行うことを特徴とする請求項 1 記載の制御弁付き副室式ガスエンジン。

【請求項 2】 前記制御手段が、前記ノッキング回避制御を、一サイクル毎、一定時間間隔毎、気筒毎のいずれか一つ又はその組み合わせで行うことを特徴とする請求項 1 記載の制御弁付き副室式ガスエンジン。

【請求項 3】 前記ノッキング回避制御が、制御弁開時期の進角、空燃比の減少、EGR 量の増加のいずれか一つ又はその組合せを含むことを特徴とする請求項 1 又は 2 に記載の制御弁付き副室式ガスエンジン。

【請求項 4】 副室と主室と、前記副室と前記主室の間に設けられ、ピストンの圧縮工程中に開弁する制御弁とを備え、ガス燃料を前記副室と前記主室に供給し、前記副室で着火させて、前記制御弁を開弁することにより、前記主室の燃焼を開始させ、排ガスの一部を吸気通路に戻し、前記主室へ予混合気とともに供給する EGR システムと、制御弁開時期と EGR ガス流量と空燃比を調整する制御手段を備えると共に、ノッキングの発生を検知するノッキングセンサを備えた副室式ガスエンジンにおいて、前記制御手段で、前記ノッキングセンサの信号からノッキングの発生を検知した時に、ノッキング回避制御を行うことを特徴とする制御弁付き副室式ガスエンジンの運転方法。

【請求項 5】 前記ノッキング回避制御を、一サイクル毎、一定時間間隔毎、気筒毎のいずれか一つ又はその組み合わせで行うことを特徴とする請求項 4 記載の制御弁付き副室式ガスエンジンの運転方法。

【請求項 6】 前記ノッキング回避制御を、制御弁開時期の進角、空燃比の減少、EGR 量の増加のいずれか一つ又はその組合せで行うことを特徴とする請求項 4 又は 5 に記載の制御弁付き副室式ガスエンジンの運転方法。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】 本発明は、ガスエンジンにおいて、主室と副室を有し、この主室と副室との間に開閉弁を設けた制御弁付き副室式ガスエンジンに関するものである。

## 【0002】

【従来の技術】 天然ガス、CO（一酸化炭素）、H<sub>2</sub>（水素）等の空気との混合が難しく、また、着火温度

が高く、着火し難いガス燃料を使用するガスエンジンには、火花点火方式や直噴射方式や予混合圧縮着火方式等がある。

【0003】 この火花点火方式のガスエンジンでは、ガソリンエンジンと同様に、吸気通路にミキサー、シングルポイント燃料噴射装置又はマルチポイント燃焼噴射装置を取り付けて、ガス燃料を予混合気にしてからピストンの吸気行程中にシリンダ内に導入し、圧縮行程後半の上死点直前で、スパークプラグにより予混合気点火し燃焼させている。

【0004】 この方式のガスエンジンは実用化されており、ガソリンエンジンよりノッキングし難い傾向があるので比較的圧縮比を高くでき、熱効率も約 37% 程度でガソリンエンジンより高い。

【0005】 しかしながら、ガソリンエンジンよりは耐ノッキングが高く、圧縮比もやや高くできるが、ノッキングの発生により圧縮比が制限され、熱効率はディーゼルエンジンに及ばないという問題や、点火装置が高価となり、また、煩雑なメンテナンスが必要となるという問題がある。

【0006】 また、直噴射方式のガスエンジンでは、ディーゼルエンジンと同様に、高圧にしたガス燃料を圧縮上死点直前にシリンダ内に噴射し燃焼させる。このガスエンジンでは、圧縮比をディーゼルエンジン並にでき、熱効率もディーゼルエンジン並となる。

【0007】 しかしながら、ガス燃料を圧縮上死点圧力以上に圧縮する装置と燃料噴射装置が必要となるため、装置が複雑になるという問題があり、また、点火装置が必要で、火花点火方式と同様に、この点火装置が高価となり、また、煩雑なメンテナンスが必要となるという問題がある。そのため、実用化されたものは僅かしかない。

【0008】 そして、予混合圧縮着火方式のガスエンジンでは、燃料を吸気通路又は圧縮行程早期に燃焼室内に直接噴射し、予混合気を上死点付近で自己着火させる新しい燃焼方式を採用している。現在は研究段階にあるが、熱効率が高く、超低 NO<sub>x</sub> のガスエンジンとなる。

【0009】 このガスエンジンでは、予混合気の圧縮上死点付近での着火のコントロールが難しく、ノッキングが発生し易く、また、運転範囲が狭いという問題がある。

## 【0010】

【発明が解決しようとする課題】 この予混合圧縮着火方式のガスエンジンの問題点を解決するために、燃焼室を主室と副室に分離し、シリンダヘッド側に設けた副室とピストン頂部の主室の間の両者を連通する連絡口に開閉弁（制御弁）を設け、副室にガス燃料、主室に空気または予混合気を導入し、圧縮点火させる制御弁付き副室式

ガスエンジンが開発されている。

【0011】この制御弁付き副室式ガスエンジンは、制御弁を副室に設けることによって、燃料供給圧力が低圧のままで、主室に供給した予混合気の圧縮着火を可能とし、また、制御弁開時期をコントロールすることにより、主室の燃焼をコントロールできるものであり、これにより、点火装置や複雑な直噴装置を不要にした圧縮着火エンジンが実現でき、しかも、高い熱効率を達成できるエンジンとして、大きな可能性がある。

【0012】しかしながら、この制御弁付き副室式エンジンにおいても、天然ガス、CO（一酸化炭素）、H<sub>2</sub>（水素）等のガス燃料が空気との混合が難しく、また、着火温度が800℃以上と高いため、着火し難いが、一旦着火燃焼が起こると一気に燃焼が進展するという特性があるため、主室から副室へ予混合気が流入して着火燃焼する時に、副室内の燃焼が激しく行われてノッキングが発生し易いという問題があり、このノッキングの発生により円滑なエンジンの運転と熱効率の向上が妨げられているという問題がある。

【0013】特に、ノッキングが一旦発生すると、エンジン各部の温度が急上昇するので、更に激しいノッキングが発生することになり、この激しいノッキングが発生すると、大きな圧力波がシリンダ内を往復して特定の周波数の圧力変化を生じて振動や音を発生するので、エンジンが損傷したり、エンジンの騒音が増大するという問題が生じる。

【0014】本発明は、上述の問題を解決するためになされたものであり、制御弁付き副室式ガスエンジンにおいて、ノッキングの発生を回避しながら、エンジンの運転を常に熱効率の高い運転領域に保つことができ、高い熱効率で、NO<sub>x</sub>排出量が著しく少なく、また、エンジンの燃焼騒音が低い制御弁付き副室式ガスエンジン及びその運転方法を提供することにある。

【0015】

【課題を解決するための手段】以上のような目的を達成するための制御弁付き副室式ガスエンジンは、次のように構成される。

【0016】1）副室と主室と、前記副室と前記主室の間に設けられ、ピストンの圧縮工程中に開弁する制御弁とを備え、ガス燃料を前記副室と前記主室に供給し、前記副室で着火させて、前記制御弁を開弁することにより、前記主室の燃焼を開始させる副室式ガスエンジンであって、排ガスの一部を吸気通路に戻し、前記主室へ予混合気とともに供給するEGRシステムと、制御弁開時期とEGRガス流量と空燃比を調整する制御手段を備え、ノッキングの発生を検知するノッキングセンサを備え、前記制御手段が、前記ノッキングセンサによりノッキングの発生を検知した時に、ノッキング回避制御を行うように構成される。

【0017】2）また、上記の制御弁付き副室式ガスエ

ンジンにおいて、前記制御手段が、前記ノッキング回避制御を、一サイクル毎、一定時間間隔毎、気筒毎のいずれか一つ又はその組み合わせで行うように構成される。

【0018】3）そして、上記の制御弁付き副室式ガスエンジンにおいて、前記ノッキング回避制御が、制御弁開時期の進角、空燃比の減少、EGR量の増加のいずれか一つ又はその組合せを含むように構成される。

【0019】また、以上のような目的を達成するための制御弁付き副室式ガスエンジンの運転方法は、次のように構成される。

【0020】1）副室と主室と、前記副室と前記主室の間に設けられ、ピストンの圧縮工程中に開弁する制御弁とを備え、ガス燃料を前記副室と前記主室に供給し、前記副室で着火させて、前記制御弁を開弁することにより、前記主室の燃焼を開始させ、排ガスの一部を吸気通路に戻し、前記主室へ予混合気とともに供給するEGRシステムと、制御弁開時期とEGRガス流量と空燃比を調整する制御手段を備え、ノッキングの発生を検知するノッキングセンサを備えた副室式ガスエンジンにおいて、前記制御手段で、前記ノッキングセンサの信号からノッキングの発生を検知した時に、ノッキング回避制御を行うように構成される。

【0021】2）また、上記の制御弁付き副室式ガスエンジンの運転方法において、前記ノッキング回避制御を、一サイクル毎、一定時間間隔毎、気筒毎のいずれか一つ又はその組み合わせで行うように構成される。

【0022】3）そして、上記の制御弁付き副室式ガスエンジンの運転方法において、前記ノッキング回避制御を、制御弁開時期の進角、空燃比の減少、EGR量の増加のいずれか一つ又はその組み合わせで行うように構成される。

【0023】以上の構成の制御弁付き副室式ガスエンジンとその運転方法によれば、ノッキングセンサでノッキングを検知した時に、エンジンの運転状況に応じて、制御弁開時期の進角、EGR流量の増加、空燃比の減少のいずれか一つ又はその組合せで、ノッキングの発生し難い運転状態にするので、激しいノッキングの発生を回避でき、常に、運転状態を良好な状態に維持できる。

【0024】なお、このノッキングには、ディーゼルノックと同様な、燃焼初期に圧力上昇率が過大になるものも含む。

【0025】

【発明の実施の形態】以下、本発明に係る制御弁付き副室式ガスエンジン及びその運転方法について、図面を参照しながら説明する。

【0026】図1は、本発明に係る制御弁付き副室式ガスエンジンの燃焼室の構成を示す図であり、図2は、制御弁付き副室式ガスエンジンのシステム構成を示す図である。そして、図3は、エンジン運転の制御フローを示す図である。

【0027】この制御弁付き副室式ガスエンジン1の燃焼室の構成は、図1に示すように、は、各シリンダ毎に、シリンダ11とピストン12の上部で形成される主室13と、この主室13と制御弁15の開閉部を介して連通する副室14とを有して構成される。このシリンダ11は、ヘッドライナ11aとシリンダライナ11bで構成され、副室14は、シリンダヘッド17に形成される。

【0028】この制御弁15は、図2に示すように、制御手段であるコントローラ(ECU)50によって制御される制御弁開時期可変装置16を介してピストン12の圧縮工程中に開弁するように構成する。

【0029】そして、図2に示すように、この制御弁付き副室式ガスエンジン1は、主室13と副室14を備えたエンジン本体10と、過給機20と、主室13にガス燃料Fを供給する第1燃料供給通路30と、副室14にガス燃料Fを供給する第2燃料供給通路35と、主室13に空気Aを供給する吸気通路40と、排気ガスGを排出する排気通路45と、EGRガスGeの再循環をするためのEGR通路47を備えて構成される。

【0030】第1燃料供給通路30は、ガス燃料Fの供給源に連結されると共に、第1燃料流量制御装置31と第1燃料供給装置32を備えて主室13に連通するように形成され、第2燃料供給通路35はガス燃料の供給源に連結されると共に、第2燃料流量制御装置36と第2燃料供給装置37を備えて副室14に連通するように形成される。

【0031】また、吸気通路40は、空気流量制御装置41を介して過給機20のコンプレッサ21を経由して主室13に連結され、一方、エンジン本体10から出る排気通路45は過給機20のタービン22等を経由して外気と連通する。

【0032】EGR通路47は、EGR弁等で構成されるEGR流量制御装置48とEGRクーラー49を備えて、タービン22より下流側の排気通路45と、空気流量制御装置41とコンプレッサ21の間の吸気通路40とを連結して形成される。なお、このEGRクーラー49は、EGRガスGeを冷却して、NOxの発生を抑制する役割を果たすものである。

【0033】つまり、ガス燃料Fを副室14と主室13の両方に供給する第1及び第2燃料供給通路30、35を備えると共に、排気ガスGの一部Geを吸気通路40に戻して、主室13へ予混合気とともに供給するEGR通路47を備える。

【0034】更に、図示しないが、ノッキングの発生を検知するノッキングセンサ51がエンジン本体10に配設される。このノッキングセンサとしては、エンジンブロックの振動、シリンダ圧、燃焼音等を検出する方法のものがある。

【0035】このエンジンブロックの振動を検知する方

法では、シリンダブロック等の取り付けられ、ノッキングの発生によって特定周波数の振動レベルが大きくなるので、この振動レベルを検出するが、この振動検出タイプには、圧電式ノックセンサや磁歪式ノックセンサがある。

【0036】そして、コントローラ(ECU)50は、エンジンの回転数、ノッキング、失火、Pmax、燃料流量、空気流量、EGRガス流量、吸気温度、吸気圧力、排気温度、排気圧力、クランク角等のエンジン情報を入力して、制御弁開時期可変装置16、過給機20、第1燃料流量制御装置31、第2燃料流量制御装置36、空気流量制御装置41、EGR流量制御装置51とEGRクーラー52等を制御して、制御弁16の開閉時期、EGRガス流量、空燃比等を調整制御するように構成される。

【0037】このEGRガス流量の制御は、EGR弁等のEGR流量制御装置51の調整制御でEGRガス流量を調整することで、また、空燃比の制御は、第1燃料流量制御装置31、第2燃料流量制御装置36の調整制御による燃料流量の調整と、過給機20の制御と空気流量制御装置41の調整制御による空気流量の調整によって行われる。

【0038】次に、この制御弁付き副室式ガスエンジン1を使用したガスエンジンの燃焼方法について説明する。

【0039】この制御弁付き副室式ガスエンジン1においては、副室14にガス燃料Fを、主室13にガス燃料Fと空気Aが混合した混合気とEGRガスGeをそれぞれ導入し、制御弁15をピストン12の圧縮行程の適切な時期に開弁すると、主室13の混合気とEGRガスGeが副室14に急速に流入し、副室14内に混合気を形成する。

【0040】そして、ピストン12が上死点に近づくと、圧縮による温度上昇で副室14内に形成された混合気が最初に着火し、この着火で燃焼したガスの膨張とピストン12の下降によって、副室14の燃焼ガスが主室13に噴出し、高温の燃焼ガスが主室13の混合気と混合し、主室13の混合気が着火する。

【0041】このとき、主室13に、適量なEGRガスGeを存在させることにより、燃焼をノッキングを起さない穏やかな燃焼とすることができる。そして、この主室13の燃焼は予混合気の自己着火であるので、穏やかな燃焼にもかかわらず熱発生率パターンはピークが高く、燃焼期間が短い燃えきりの良い燃焼となる。

【0042】この全体の熱発生パターンは、燃焼の前半における副室14の燃焼による低いピークと、後半における主室13の燃焼による高いピークが現れる二山のパターンになっている。この前半の低いピークが後半の燃焼による過大な圧力上昇を抑え、静粛な燃焼を実現する役割をしている。しかも、NOxの排出量はディーゼル



エンジンの1/10~1/100となる極めて低い値となる。このような燃焼を常に行うことにより、高効率で超低NOxの燃焼となる。

【0043】そして、この制御弁付き副室式ガスエンジン1の燃焼は、制御弁15の弁開時期、EGR率、空燃比によって大きく影響を受けると共に、過大なノッキングの発生と失火によって運転条件が制限されるので、常に最適な条件に保つ必要がある。特に、ノッキングの発生は、制御弁開時期、EGR率の影響が大きい。

【0044】そこで、ノッキングセンサ51の検出値を10 入力するコントローラ50によって、ノッキングの発生と、エンジン各部温度、吸気圧力、排気圧力等のエンジンの運転状態を運転中に常時監視して、ノッキングが発生していない時には、運転指令に応じた最適条件に設定し、また、ノッキングが発生した時は、制御弁開時期、EGR率、空燃比を、一サイクル毎、あるいは、一定期間毎、更には必要に応じて気筒毎に制御して、常に最適な燃焼を実現する。

【0045】次に、エンジンの運転フローについて、図3を参照しながら説明する。

【0046】エンジンの運転が開始され、制御フローがスタートすると、ステップS11で、エンジンの運転に関する運転指令と、エンジンの状態を示すエンジンの情報を読み込む。

【0047】この運転指令には、目標のエンジンの回転数や負荷等が含まれ、エンジンの情報には、エンジンの状態を示す、エンジンの回転数、ノッキング、失火、Pmax、燃料流量、空気流量、EGRガス流量、吸気温度、吸気圧力、排気温度、排気圧力、クランク角等が含まれている。

【0048】そして、次のステップS12で、この読み込んだエンジンの運転指令に運転停止指令が有るか、否かを判定し、有れば、ステップS18に行き、エンジンの運転停止処理を行い、この制御をストップする。

【0049】このステップS12で、運転停止指令が無ければ、次のステップS13に行き、読み込んだエンジンの運転指令とエンジンの情報に基づいて、燃料量、空燃比、制御弁15の弁開時期、EGRガス流量等の運転パラメータを設定又は変更の処理を行う。

【0050】そして、次のステップS14で、ノッキング40 が発生したか否かを判定し、ノッキングが発生していないと判定した場合には、ステップS15の運転最適化・低燃費化処理を行って運転パラメータを更新して、ステップS17で所定の時間の間、エンジンの運転を行い、ノッキングが発生していると判定した場合には、ステップS16のノッキング回避処理を行って運転パラメータを更新して、ステップS17で所定の時間（エンジンの制御のインターバル）の間、エンジンの運転を行う。

【0051】このステップS15の運転最適化・低燃費 50

化処理は、空燃比を薄くする処理、副室弁開時期を遅角又は最適化させる処理、EGRガス流量（EGR率）を減少する処理を含み、一方のステップS16のノッキング回避処理は、空燃比を濃くする処理、副室弁開時期を進角させる処理、EGRガス流量（EGR率）を増加する処理を含む。

【0052】そして、このステップS17の所定の時間間のエンジンの運転を終了したら、ステップS11に戻り、エンジンの運転をエンジンの運転停止指令が出るまで、この制御フローに基づく運転を継続する。

【0053】この構成の制御弁付き副室式ガスエンジン1とその運転方法によれば、ノッキングセンサ51とコントローラ50によりノッキングの発生を監視しながら、制御弁開時期、EGR率、空燃比を、一サイクル毎、一定期間毎、又はシリンダ毎に、フィードバック制御等による方法でコントロールすることにより、ノッキングの発生を防ぎながら、高い熱効率点でエンジン運転を行うことができる。

【0054】

20 【発明の効果】以上に説明したように、本発明の制御弁付き副室式ガスエンジンとその運転方法によれば、ノッキングの発生を監視しながら、制御弁開時期、EGR率、空燃比を、一サイクル毎、一定期間毎、又はシリンダ毎にコントロールすることにより、常時ノッキングの発生を防ぎながら、常に高い熱効率点でエンジン運転を行うことができる。

30 【0055】そのため、ノッキングの発生を回避しながら、常に熱効率の高い運転領域内で、高い熱効率で、NOx排出量が著しく少なく、また、エンジンの燃焼騒音が低い状態で運転することができる。

【0056】従って、低燃費、低公害エンジンが実現でき、更に、通常のディーゼルエンジンでは着火・燃焼が困難なアルコール燃料、ガソリン等の液体燃料にも適用できるエンジンとなる。

【図面の簡単な説明】

【図1】本発明に係る実施の形態の制御弁付き副室式ガスエンジンの燃焼室の構成を示す図である。

【図2】本発明に係る実施の形態の制御弁付き副室式ガスエンジンのシステム構成を示す図である。

40 【図3】本発明に係る実施の形態の制御弁付き副室式ガスエンジンの運転の制御フローを示す図である。

【符号の説明】

1 副室式ガスエンジン

12 ピストン

13 主室

14 副室

15 制御弁

40 吸気通路

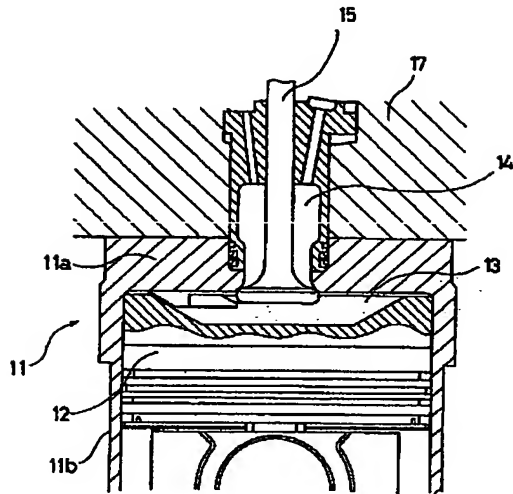
47 EGR通路

48 EGRガス流量制御装置（EGR弁）

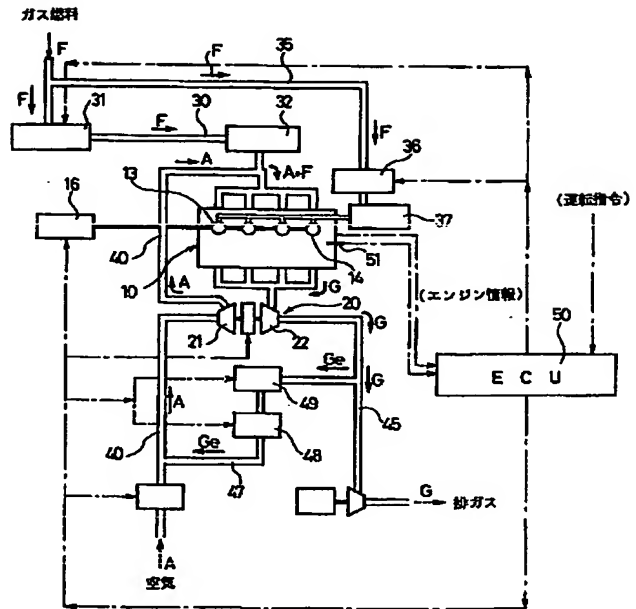
- 49 EGRクーラー  
 50 コントローラ (制御手段)  
 51 ノッキングセンサ

- F ガス燃料  
 G 排気ガス  
 Ge EGRガス

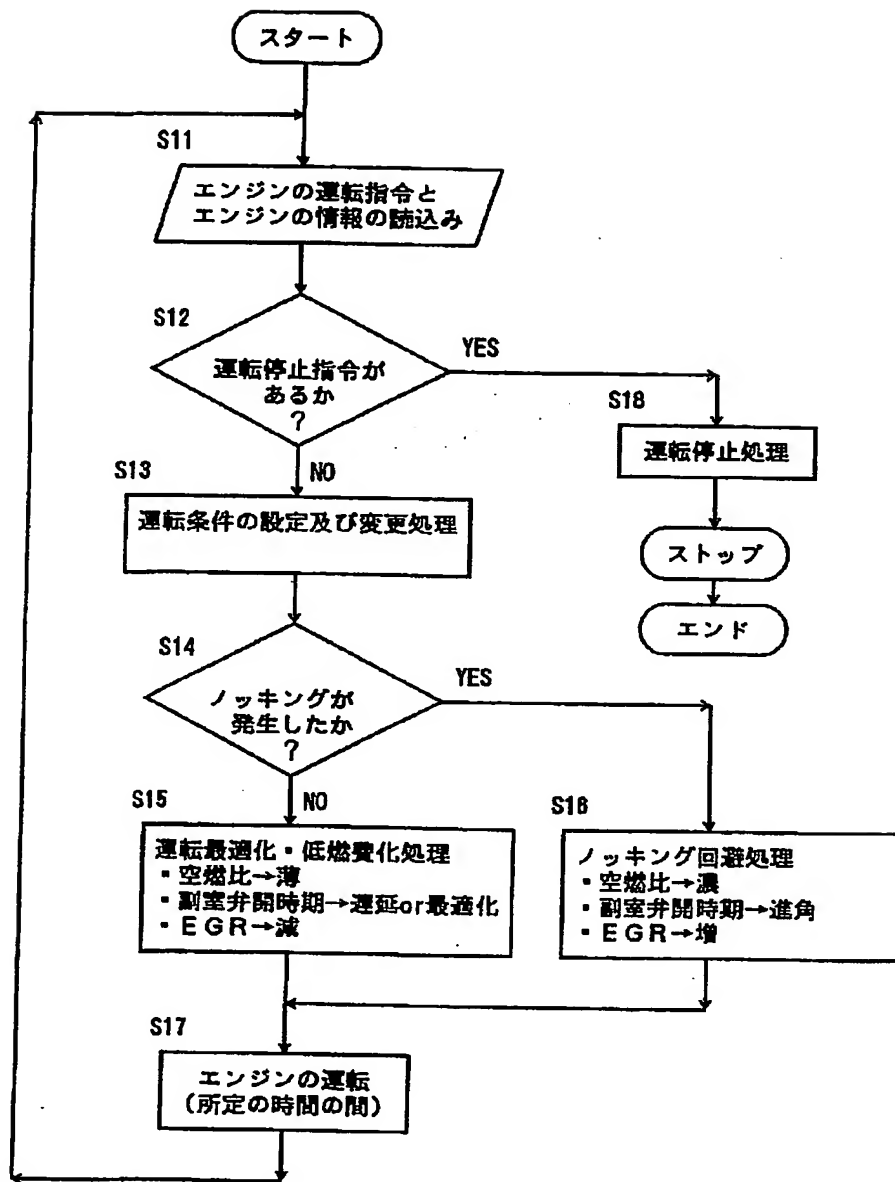
【図1】



【図2】



【図 3】



フロントページの続き

(51) Int. Cl.<sup>7</sup>

F 02 B 19/10

F 02 D 15/04

21/08

41/02

41/22

43/00

識別記号

3 0 1

3 1 1

3 5 1

3 5 5

3 0 1

F I

F 02 B 19/10

F 02 D 15/04

21/08

41/02

41/22

43/00

テマコード (参考)

P

G

3 0 1 A

3 1 1 Z

3 5 1

3 5 5

3 0 1 E

3 0 1 N

45/00 3 4 5  
3 6 8

F O 2 M 21/02

3 0 1

25/07 5 5 0

5 7 0

45/00

F O 2 M 21/02

25/07

3 0 1 W

3 0 1 Z

3 4 5 B

3 6 8 A

G

L

P

3 0 1 A

3 0 1 J

5 5 0 G

5 5 0 R

5 7 0 Z

F ターム(参考) 3G023 AA05 AA06 AB05 AC03 AC04  
AC07 AD23 AD30 AF00 AF03  
AG03  
3G062 AA00 BA00 BA02 CA00 DA01  
DA05 EA10 ED01 ED04 ED08  
GA18  
3G084 AA01 AA05 BA00 BA09 BA20  
DA38 EC01 FA25 FA39  
3G092 AA07 AA11 AA17 AB08 AB09  
BA04 DD09 EA01 EA03 EA05  
FA16 FA17 GA00 HB00X  
HC05Y HD07X HE00X  
3G301 HA05 HA06 HA11 HA13 HA22  
JA22 MA00 MA01 NE23 PC08Z